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FROM THE BOARD OF EDITORS

The management of industrial research must be an inherently dynamic function for responsiveness toward corporate goals. Its dynamism means that the theories governing its practices and actions are subject to change, and the best means to portray current conditions and advanced thinking is the periodical journal. That is the *raison d'etre* of RESEARCH MANAGEMENT, now in the fourth year of publication. It has experienced a steady growth not only in our nation, but throughout the world. We have subscribers in 29 foreign countries.

We want our journal to reflect the desires and needs of the readers. It has been suggested that this end can better be achieved by having a section devoted to "Letters to the Editor" in which your comments and views will be recorded. We thus solicit your letters, believing they will add interest and value to our journal.

Another suggestion: We are thinking of starting a section devoted to "Who Has the Answer." The intent will be to publish inquiries of general interest to research managers, on an anonymous basis, and to invite answers to the inquiries in subsequent issues.

Both of these features should make the journal more valuable and more interesting to all readers. If comments and inquiries from the floor of IRI meeting are valid criteria, there will be no shortage of material for these features. Let us hear from you!

ABOUT THIS ISSUE

At the Annual Meeting of the Industrial Research Institute, May 2, 1961, Max Tishler was awarded the Institute Medal: "For dynamic leadership in industrial research and development; for scientific inspiration and guidance of his co-workers; for skillful coordination of the overall technical effort of his organization in the attainment of commercial success in the production of vitamins, antibiotics, pharmaceuticals and chemicals; and for his active participation in the application of science to the public health and welfare." The remarkably stirring address which he delivered on that occasion "The Debt of Discovery to Learning" is presented as our first article. Dr. Tishler is President of Merck Sharp & Dohme Research Laboratories, a Division of Merck and Co., Inc.

In 1959, a task group was appointed to make a study of the titles of research and development personnel in IRI member companies. One objective was to determine the feasibility of a standardized, uniform title structure that would win general recognition as an indication of level of achievement and type of responsibility. The report of the task group is presented as our second article. "Scientific and Administrative Position Titles and Level Descriptions" is a comprehensive document that attests not only to the diligence of the men charged with the task, but also to the cooperation of the member companies that supplied the needed data. The task group consisted of 12 persons with Galen J. Wilson, Director of Research, The National Cash Register Company, as chairman.

Our third article discusses an important, frequently overlooked aspect of human relationship in a laboratory. The supervisor's suggestion to a bench worker may be variously interpreted as a command, a high-priority item to favor, a remark to be ignored

—or it may be taken for what it was intended to be—a casual suggestion that the bench worker can accept or reject according to his judgment. The supervisor who wants his suggestions to be so interpreted must know the art, and he must know his people. "The Art of the Stimulating Casual Suggestion" tells of methods that can be used to achieve the desired rapport. The author is F. E. Butterfield, Manager, Equipment Engineering Laboratory, Electronic Defense Laboratories, Sylvania Electric Products, Inc.

The increased emphasis on research and development has been accompanied by greater demands for the services of writers. In contrast to scientists and engineers, writers are a comparatively recent addition to research and development staffs and their place in the hierarchy of professional men is yet to be established. Many writers are chafing at the status presently accorded them and Owen Thomas in his paper "The Writers' Choice: Corporation or Campus" tells why. We are glad to present the case of this important and sophisticated element of the modern research organization. Dr. Thomas writes from experience. Formerly with Space Technology Laboratories, he is now a member of the faculty of Indiana University.

"Seven years from test tube to tank car" is a figure of speech in the chemical industry. A project may take less time than that; it has also been known to require a longer period. In any event, the journey is a long and costly one, and milestones to indicate the progress are highly desirable. In "A Technique for Improving Research and Development Communications" Dr. Herschel H. Cudd, President of AviSun Corporation, discusses some terms that are useful to characterize the stages of transition.

Continuing the practice initiated in the Winter 1960 issue, we now present a review of a book on a subject of interest to those engaged in the management of research. "Automation—Its Impact on Business and People" was written by Walter Buckingham, Director of the School of Industrial Management, Georgia Institute of Technology. It is reviewed by Finn J. Larsen, Vice President, Research, Minneapolis-Honeywell Regulator Company.

PRESENTATION OF THE INDUSTRIAL RESEARCH INSTITUTE MEDAL* TO MAX TISHLER

Boca Raton, Florida, May 2, 1961

Left to right: Robert W. Cairns, Director of Research, Hercules Powder Company; Max Tishler, President, Merck Sharp & Dohme Research Laboratories Division, Merck & Co.; and Robert G. Chollar, Vice President, Research and Development, The National Cash Register Company.

* The Medal was established by the Institute in 1945 to "recognize and honor outstanding accomplishment in leadership in or management of industrial research which contributes broadly to the development of industry or the public welfare." It is awarded at the discretion of the Board of Directors of the Institute upon recommendation of its Committee on Awards. Previous medalists were: Willis Rodney Whitney, Charles Allen Thomas, Games Slayter, Vannevar Bush, Frank Baldwin Jewett, Randolph Thomas Major, Roy Chester Newton, Eger Vaughan Murphree, Mervin J. Kelly, Ernest Henry Volwiler, Victor Conquest, Clifford F. Rassweiler, Elmer William Engstrom, Frank K. Schoenfeld, and Augustus Braun Kinzel.

THE DEBT OF DISCOVERY TO LEARNING*

MAX TISHLER†

President, Merck Sharp & Dohme Research Laboratories, Division of Merck & Co., Inc., Rahway, New Jersey

It is indeed difficult for me to express adequately my feelings tonight. I am deeply honored at being selected to receive the Industrial Research Institute Award and very conscious of how much the achievements you have cited have, in fact, resulted from the work of others. I am grateful to the members and officers of The Institute for this expression of their scientific esteem. I am even more grateful for the scientific stimulation and the personal pleasure my associations with you have always given me. I find I am most conscious tonight of the competence and dedication of the many scientists at Merck Sharp & Dohme and outside it, who together have formed a community whose contribution to science and to humanity you have honored here tonight, and of the farsighted men in Merck management who have in good times and bad consistently encouraged scientific research. I am grateful to

* This is the text of the address given by Dr. Tishler on the occasion of the presentation to him of the Medal of the Industrial Research Institute, Boca Raton, Florida, May 2, 1961.

† After obtaining a B.S. degree at Tufts University and a doctorate in organic chemistry at Harvard University, Dr. Tishler served the latter institution as research associate and instructor. For the past quarter of a century he has been with Merck & Co. where he demonstrated his eminence in science and as a leader of scientists. The Institute Medal is the latest of a series of awards and honors that he has earned in his career.

have been associated with them and to be able to accept for them and for myself the Award you have made tonight.

In the past 25 years discovery and invention have produced a great transformation in our society. So profound has been this change that those of us who have participated in it could scarcely have conceived of its extent when we left the university to devote our lives to research in industry. These have been good years to us as scientists and as directors of what Sumner Slichter has called "the industry of discovery." [1]

I need not recall to you the brilliant achievements of industrial research that have taken place during this quarter century. Instead of looking at the past, let us look at the future and let us ask ourselves a nagging question that I am sure has tugged at the sleeve of each of us more often than we like to think. Is it going to be more difficult for us in the next 25 years to make new discoveries of the same magnitude as those that have come from our laboratories in the past?

I am sure that everyone in this room feels the pressure for discoveries. We all know they are coming, but we do not know when. The world of knowledge is so tiny in relation to the universe of ignorance that the result is inevitable. In my own field—pharmaceutical research—we are still wandering around pretty much in the dark, treating the symptoms of disease because we know so little about its causes. Our ignorance of both biology and chemistry is so monumental that we have to depend much too often on hunch plus plain trial and error even for symptomatic results. How can one question the productiveness of the years ahead if we sustain our capacity for discovery?

This, then, becomes the key question: How can we sustain our capacity for discovery? This capacity is dependent, in the final analysis, on an endless supply of educated people and an inexhaustible fund of basic knowledge. To what source of intellectual activities should we look for the new basic concepts of science from whence flow our discoveries and inventions? Can we be sure that the organization of science—today's and that of the years

ahead—will motivate and bring forth such fundamentals as the quantum theory, Gibbs' phase rule, the theory of relativity, antibiosis, antimetabolites, radiation, and radio-active fission? Where shall we find the future scholars and giants of science, such as Einstein, Fermi, Nernst, Stanley, Schroedinger, Pauling, and Krebs, who have made permanent imprints on discovery and invention?

Every time I think of the future of research, I find myself coming back to the debt that discovery owes to learning. I come back to the cradle of research, to the natural, nurturing shelter of freedom of inquiry—the university.

The first real home of scientific research was the university, for research is inseparable from scholarship. There it multiplied disciples dedicated to cutting paths through the unknown and to creating new knowledge and understanding. The university provided the atmosphere, the sustenance, and the motivation for complete freedom of inquiry. Science paid its debt for all this nourishment by helping the university to carry out the important mission of adding to the nation's resources of educated men and women. Research was an essential part of teaching for both the university and its scholars.

I am vitally concerned with the university's future, because it is our future too. Unless it does its job well, neither I nor any other industrial research director will be able to sustain our capacity for discovery. It is for this reason that I would like to examine with you today some of the forces at work within the university, forces that will ultimately influence the success of every laboratory for which we here today are responsible.

In the past 20 years the role of the university in our national life has changed drastically. The logic of survival in the modern world has dragged it from the quiet center of our society right into the maelstrom of its periphery. After Pearl Harbor we had to denude our campuses to win the war. And we are now depending more and more heavily on the intellectual resources of the universities to win the peace. The origin of so many of President Kennedy's appointees is only the most recent and dramatic public evidence of this dependence.

We can see the changing role of the universities most clearly in the area of scientific research. To put this into perspective, let us first look at the growth of research and development in the nation as a whole. In just 13 postwar years total R&D expenditures multiplied six times—from 2.1 billion dollars in 1946–47 to 12.4 billion dollars in 1959–60. The biggest motivating force in this multiplication, of course, has been the Federal Government. Its share of R&D expenditures rose during this period from about 25 to 70% of the total. Through its control of most of the funds, the Federal Government now is in a position to dominate U.S. research.

With that brief background, let us look at what the Federal research dollar is doing to the university. In 1940 the Government spent in the neighborhood of 15 million dollars for R&D in colleges and universities. By the current fiscal year that figure had multiplied about 60 times to nearly 900 million dollars. Expressed in other terms, about 75% of all academic research in the physical and life sciences is now being paid for with tax money.

This enormous increase in research funds now places the Government firmly on the university campus and has brought with it a whole new way of academic life. Although most of us have been heartened by this attention to the universities, closer examination of what is happening leads us to an inescapable conclusion. What we are witnessing is no real resurgence of interest in the intellect nor is it a rising dedication to learning. Rather, it is an attempt to mobilize science through our educational system for the single-minded purpose of solving the immediate problems of national health and security. The Government agencies are supporting university research, not to help the institutions nor even to help freedom of inquiry, but for the sole purpose of buying new knowledge useful to their missions.

This situation is not visible to the naked eye. It is obscured behind a golden curtain of nearly a billion dollars. We have to penetrate that golden curtain to find out what is really going on.

One way to measure what is going on is to measure the pro-

portion of Government research funds actually being used for basic research. Let us look at the record.

The facts came as a great surprise to me. In the 1958 fiscal year the research directors of American industry were able to persuade their profit-minded managements to spend 7% of their research budgets for basic research. The Federal Government, with all its responsibilities for the advancement of science, did no better. Its percentage contribution was exactly the same. The source for these revealing figures is the National Science Foundation,[2] which admits that the figures are not perfect, because of the enormous difficulties inherent in both the definition of basic research and the application of the definition. But the maximum potential error is nowhere near great enough to allow us to escape the obvious.

The American people, who think they are putting 9 billion dollars a year of their tax money into the support of scientific research in the United States, are being misled. They are paying mainly for the exploitation of existing knowledge. Through the whole decade of the fifties, only 7 cents out of every Federal research dollar went into basic research for the purpose of increasing the store of existing knowledge. Moreover, much of this money was committed to basic research, directed towards an end objective established by some agency of the Federal Government. I submit that this is not sound judgment. In view of the high scientific content of the struggle against communism, the nation cannot afford so small a commitment to the basic source of all discovery.

How does the Government support university research? It does this in two ways. First, it makes contracts with the institutions for the investigation of particular problems, the answers to which are important to the contracting agency, such as the Air Force or the Atomic Energy Commission. Over 40% of the Government's funds, for instance, are going to the university-administered research centers, most of them huge semi-autonomous institutions such as the AEC's Argonne National Laboratory, which is run by the University of Chicago. These centers are doing some basic research but most of their effort is going into practical appli-

cations of existing knowledge. In addition, the universities themselves are doing some applied research and a little development work for the Government under contract.

The second way the Government buys new knowledge from the universities is through grants in support of basic research in the areas of interest to the granting agency. The National Institutes of Health and—to some extent—both the AEC and The National Science Foundation are prominent supporters of this kind of research.

Although there is as much difference between these two methods of buying knowledge as there is between applied and basic research, the fact remains that the agencies of Government are primarily interested in only one of the functions of the university—its ability to do research in defined areas of science. As you would expect, they spend their money only where they think they can get the best results for the fewest dollars.

Let us look at the results of this policy. In fiscal '59 only 287 out of a total of 1,940 institutions of higher learning received Federal money for research. Well over half of this money—57% to be exact—went to only 5 of these institutions, and 79% of all Federal money for college and university research went to only 20 out of the 1,940 institutions. These are the universities whose graduate and research facilities in the sciences are already the most highly developed.

What has this done to the scientific capabilities of these institutions? It has helped make the good, better; the better, best; and the best, affluent. It has helped them all become bigger, as they have used Federal research funds to build up their manpower. If this policy should continue for any length of time, the result will be inevitable: no first-class scientist will be willing to join any but a handful of universities. The students in the remainder—which means the overwhelming majority of science students in the United States—will get a second-rate education.

What is happening to the handful of universities which have been receiving large sums of Government money for research? As

you might expect, it has made these institutions dependent on the Federal Government for a high percentage of their income, as can be seen from a recent survey[8] by Harvard of seventeen of the largest recipients of funds. This survey showed that in 1958–59 Cal Tech topped the list of Federal dependents. U.S. Government research money that year accounted for 83.6% of Cal Tech's total income, or 50.7 million dollars out of the institution's 60.7 million dollar budget. The percentage of Federal dependence for M.I.T. was 78.2%; Johns Hopkins, 67.2%; Chicago, 61.2%; Princeton, 55.5%, etc., down through Harvard, 19.4%, to Maryland, 15%. Just a little under half of the 1.1 billion dollar total income of seventeen universities came from the Federal Government for sponsored research.

I am convinced that the Government agencies that supply these funds are just as aware of the dangers inherent in this financial dependence as are the universities themselves. They have tried to avert these dangers by various administrative mechanisms and regulations too complicated to burden you with today. They have made extensive use of panels of outsiders both to review and to recommend. As a result, their research programs have thus far been remarkably free from the criticism that they are trying to dictate the course of U.S. science or even to interfere with the individual investigator's freedom to follow his own bent.

Having said this, though, I should like to qualify it with a quotation from a report by the National Science Foundation published in 1958. The report, entitled, "Government-University Relationships in Federally-Sponsored Scientific Research and Development," was signed by Alan Waterman, Foundation Director, and Detlev W. Bronk, Chairman of the National Science Board:

"The distinction between choices made because of genuine interest and curiosity of the staff members and those made because funds were available for a particular field is not easily drawn. Although the usual statement of the research staff is that they are doing work of their choice, the statement is in part offset by the parallel reply to the following question: 'If the same funds were available to a department without strings of any kind or interests of spon-

soring agencies—except that the money be used for research—would the staff of the department be doing the same research?' The answers are often qualified. The reply, of course, is determined in considerable degree by the objectives of the sponsoring agency. It would be unrealistic to claim that Federal contracts and grants for research at universities have exercised no influence over the types of fields of research undertaken by the institutions."

One cannot help but wonder to what extent the muted tone of this and other criticism is due to the fact that scientific research, historically starved, is enjoying its new age of affluence. As Dr. James Shannon, Director of the National Institutes of Health, said as far back as 1957:

"For the first time in the history of medical research, either in this country or abroad, the limitation on progress is due more to manpower and facilities than to moneys available for current support of research."

Affluence aside, the observations by Waterman and Bronk bring into focus the very problem of freedom of research—the right to select and study problems in the best tradition of the university, where motivation of inquiry rests solely with its scholars. We may well ask ourselves whether Bohr and Fleming could have successfully described their studies in project proposals to supporting agencies. Waterman and Bronk do not lessen our apprehension for the independence and freedom of the universities when 70–80% of university research originates from Federal funds administered by agencies charged with responsibilities for the national interest, as defined by Congress.

Research guided by the national interest may sound like a sensible idea to many educated people outside the field of science. But, when the unknown is such a large universe, great discoveries are seldom made by direction. They are made because there are laboratories where trained and dedicated men can work, free from direction, on problems of their own choosing. This is the ancient pattern of university research. When I was a graduate student at Harvard, my professor, the eminent organic chemist, Elmer Peter Kohler, had a regular appropriation of $10,000–15,000 for

research, and when I became an instructor I received $1,500 for the same purpose. No one asked us what we were going to do with this money or even hinted at what line of inquiry we should pursue. Who can tell, in advance, what part of the unknown will be in the interest of either nation or of humanity until it has been discovered?

Because proportionately so little of this kind of research is going on, despite the availability of enormous funds to finance it; because so much top talent in our universities is being wasted on short-term objectives; because Federal funds are not being used to strengthen the science facilities of more than a few of our institutions; I say that the first debt of discovery to learning—the accumulation of knowledge—is beginning to mount to such proportions that we had better concentrate on the job of paying it off. We must provide the university with the means to carry out research with freedom and self-motivation in line with the best tradition of the university.

The second debt of discovery to learning is its debt to teaching. This again brings us back to the university. It is here that our future scientists are created through the indispensably combined influence of teaching and research. Graduate education in the sciences depends just as much on teaching as it does on research.

The invasion of the university by Federal funds since World War II has lured many top scientists away from teaching into research projects sponsored by Government agencies. The temptation to accept large research grants, to direct large groups of scientists, and to reap the rewards of recognition and status that follow publication of research results is an overwhelming temptation that is hard for mere human beings to withstand.

In far too many instances this has made research project directors out of men who would otherwise be devoting a substantial portion of their time to turning out the scientists of the future. It has weakened the loyalty of these men for the community of scholars—present and future—which in reality is the university. For this ancient and honorable loyalty it has substituted loyalty for their

own research projects and for the Government agency that nourishes them. In many instances it has cut off completely the undergraduates from the inspiration of the best scientific minds in their institutions.

This has, in fact, become an alarming trend. Some universities have been using Government funds to pirate brains from rival campuses, offering top scholars such inducements as high salaries, the opportunity to direct large research projects, and complete freedom from the "burden" of teaching undergraduates. In calling attention to these practices in a speech two months ago, Dr. Robert F. Goheen, President of Princeton University, labeled them a "marked and dangerous trend" in American higher education, a trend which, he said, was keeping top scholars out of college teaching.

This trend has even affected graduate training, since professors on contract and grant programs often have little time to spare for teaching even graduate students. From the professors' point of view, it is more efficient to concentrate attention on a handpicked team of post-doctoral assistants who can be most helpful in getting the project completed. All too often, too, the graduate student, needing the financial assistance offered by a sponsored research project, may be lured away from the field of his interest by an oasis of dollars completely surrounded by what, to him, is an arid intellectual desert. He may eat but he may never recross that desert to the place where his heart lies and where a great teacher might have fanned the creative spark of genius into a flame that would have lighted a chapter in the history of science. In the creation of the scholars of science, the freedom to learn is as important as the freedom to inquire.

Teaching as a primary function of the university receives paltry support from the Government agencies that provide the flow of funds for university research. Although an increasing number of grants are available for training programs in the form of fellowships and research assistantships, they are designed to

serve only one master: research. The Government is single-minded about this; Congress would not allow it to be otherwise.

Another direct effect of federally sponsored research on teaching is the imbalance forced upon the universities by the failure of Government to pay all the indirect costs of research. This means that the university must underwrite these indirect costs out of other funds. All too often this financial drain hits the budget for teaching.

This drain is particularly heavy in the medical schools because of the persistent refusal of Congress to allow the National Institutes of Health to pay more than 15% for the indirect costs of NIH-sponsored research. It is generally agreed that indirect—or overhead—costs of research run in the neighborhood of twice that amount and, in fact, the Defense Department generally pays the universities upward of 30% for indirect costs.

The result of this lack of Congressional understanding was revealed by the National Science Foundation in a report of a study of research funds for medical schools during the fiscal year 1958. In that year the Federal Government picked up the tab for only 53.5% of the indirect costs of federally sponsored research in the medical schools. The schools had to pay for the other 46.5%. This meant that the medical schools had to find 6.6 million dollars of their own scarce funds to help support the research the Government had asked it to conduct. Is it difficult to understand under these circumstances why the medical schools have accumulated such an alarming number of teaching vacancies that they cannot fill? I feel sure that our legislators do not realize the extent to which their action here is reaching into university administration and determining the balance that should exist between teaching and research on the campus.

John C. Weaver[3] in his recent article, *What Federal Funds Mean to Universities Today,* made this pertinent observation:

"Many an outstanding teacher is failing to plant the invaluable seed for another generation of scholars, simply because some Government agency be-

lieves his research is indispensable to their immediate purpose . . . Whenever plans appear which will remove an outstanding professor from the classroom or seminar table, we have an obligation to take a long look at whether the research results will weigh as heavily in the scales of posterity as will the Ph.D. students he will train and who will carry his multiplied skills and insights into the future."

It is these "multiplied skills and insights" that are the basic resource of science. If Government continues to treat the universities as mere discovery factories instead of as communities of scholars capable of multiplying themselves, then we shall inevitably reach the point of no return. Then science will no longer be able to grow at the pace the nation expects and needs in an era when the postponement of discovery may mean the twilight of freedom.

The university, which is the only instrument for maintaining a proper balance between teaching and research, is losing its control over the situation. As a source of money for research—a major control device for enforcing this balance—it has long since abdicated its primacy to Washington. It still has the final say on paper, but in reality the lines of communication too often go directly from the scientist on the campus, who wants the funds, to the agency in the nation's capital that wants to buy the research. There are outstanding exceptions to this, which all of us could probably name, but these are relatively few.

The question now is not: How can we live with this imbalance between research and teaching? It is: How can we restore to the university the ability to regain control over the situation? There may be no easy way to answer this question. But, as I see it, there is no alternative in view of the imperatives of the time in which we live.

Let us now summarize the patterns that have been emerging during the past two decades from the impact of Government support of research on our institutions of higher learning.

(1) The greatest patron in the history of science—the United States Government—has moved university research and development from the attic down into the front parlor.

(2) The Government is getting from the universities what Congress has asked it to get: in a nutshell, applied—and some basic—research to support the missions of the military and the National Institutes of Health.

(3) But behind this golden curtain, through which little bold criticism has made its way, all is not well. Government funds have weakened—not strengthened—the university's capacity to perform its two major functions in the field of science: free, untrammeled research and the production of high-quality scholars.

(4) In other words, the Government, in the process of spending on the campuses what is fast approaching in excess of 1 billion dollars a year for research and development, has been exploiting our major scientific resource—the university—by turning it into a factory for the production of discoveries out of existing resources. It has done very little to replenish these resources and to repay the mounting debt of discovery to learning.

(5) If discovery and invention are to grow at a healthy rate in the future, we must find ways of repaying that debt.

In assessing the debt of discovery to learning, I am not unmindful that it is nowhere more apparent than in the laboratories of the members of this Institute. Our past, present, and future are intimately related to research in the university and to its ability to turn out scholars of high quality. Although I recognize the industry's contribution to our institutions of learning is also in need of critical examination, this is not my subject today. In any event, the determined Government forces that have swept into our universities overpower any effort that industry can realistically muster.

Washington is on the campus, and I am convinced it is there to stay. The blessing is mixed, but it is still a blessing. Our problem is to see that the traditional values of our universities are preserved and not destroyed under these conditions.

To restore the proper emphasis to teaching and to restore an atmosphere of complete freedom in research within the university,

it seems to me that we must move to separate from the university campus most, if not all, of the mission-oriented applied research and development and even mission-oriented basic research. This mission-oriented R&D could be handled in separate research institutes administered either by universities or private organizations.

The universities must be provided with funds for the kind of free, creative, and self-stimulated pursuit of new knowledge that have been largely responsible for the great bursts of insight in the past and are so essential for the future. It is important, too, that Government appropriations for research should no longer be divided among a handful of universities, solely on the basis of the criterion of past and present excellence. They should be spread far more widely in order to build the science capacities of an increasing number of institutions and to make excellence in both research and teaching available to a higher proportion of our next generation of students. Funds for university research should clearly include an adequate allowance for the indirect costs of this research, so that the universities can maintain integrity and balance, within all their academic activities.

If I were asked to suggest a way to find another Einstein, I would say that there is no better way than for each of us to discuss with his Senators and his Congressman the measures and the means to repay the mounting debt that discovery owes to learning.

In the long history of man, no civilization, basking in the midday sun, has been able to see the shadows lengthening on its destiny. Darkness has always closed upon their world before its coming seized possession of men's minds and galvanized their wills to repower those institutions that would turn the tide against their enemies.

For us, this is such a time. Let us not forget that the university, first home and mother of science, is one well-spring of that intellectual power that can turn the tide.

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SCIENTIFIC AND ADMINISTRATIVE POSITION TITLES AND LEVEL DESCRIPTIONS

REPORT OF A TASK GROUP OF THE INDUSTRIAL RESEARCH INSTITUTE, G. J. WILSON,* TASK GROUP CHAIRMAN

Introduction

In 1958 a special committee of the Industrial Research Institute selected the topic "Job Status as an Award for Scientific and Administrative Accomplishment" to determine the feasibility and value of study group meetings. In early 1959 two such meetings were held. The proceedings were reported in this journal, III, No. 4, 227 (1960).

The study group participants (representing approximately 40 companies) concluded that a questionnaire on job status would be worthwhile if a suitable one could be designed. With remarkable insight, they decided not to develop the questionnaire themselves, but to recommend establishment of a Task Group (Appen-

* Galen Wilson began his career with The National Cash Register Company shortly after graduation from Antioch College. Starting as a research chemist in 1941, he was promoted five years later to Head of the Chemical Research Department. Subsequently, he became Assistant Director of Research and Assistant to the Vice President. In 1959 he assumed his current assignment as Director of Research of that organization.

dix I) with a charter to devise a questionnaire and coordinate the replies.

This paper presents and analyzes the responses of IRI member companies to the questionnaire. The results of the project are remarkable in the breadth of interest and depth of participation that they indicate. Furthermore, the results show the productivity of the specific Task Group used in this study, and, in general, reflect favorably on the use of such groups to implement the suggestions and recommendations generated at study group meetings.

The Proceedings of the initial two study groups had this to say about the job status question:

"How is it possible to compare the status of people in like positions in different companies as long as we have no standard job titles common to all industries and among all categories of professional people? Men of equal training, ability, and experience may be classified as Research Chemists by one firm, as Senior Scientists by another, and as Members of the Technical Staff by a third."

It further stated, "The conferees agreed that the attainment of uniform job titles throughout industry could be extremely helpful, but that the goal is probably unattainable." However, it was "agreed that it should be possible to write down the broad functions or basic objectives in and the responsibilities of a position." It was also concluded that "the details of the major responsibilities assigned to a position can be agreed upon. Undoubtedly, the serious language problem inhibits flow of personnel information among companies . . . in university life the titles of professional people have meaning to the general public as well as to their colleagues, but this happy state of affairs has taken centuries to attain. It seems too much to hope that diverse industries can realize a like uniformity of titles in our lifetime."

During the course of this study, it has become apparent that achieving a uniform title and level structure may be accomplished within a reasonable time.

This report is presented in two sections. *Section I* deals with

the basic study program conducted to determine the feasibility of attaining the major objectives. *Section 2* is a brief consensus among 136 companies as to a system of titles compatible with the seven level descriptions proposed.

SECTION 1

Objective

To develop a title structure which provides *meaningful* recognition of professional growth and status of an individual by the scientific community and the general public.

A second benefit would be to create a useful base for inter-industry communication of information relative to common problems of research administration.

Background

During the summer of 1959, the task group requested 31 IRI companies to submit position descriptions and salary ranges for analysis. Evaluation of the material disclosed many approaches to language and titles used by the companies.

The information also revealed a broad range of breakpoints in descriptions, responsibilities, and salary. The interpretation of the position descriptions of participating companies with respect to the broad range of breakpoints was impractical due to the lack of detailed knowledge concerning the company organizations. Therefore, the task group developed seven broad level descriptions for five scientific and two administrative categories and these were circulated to the participating companies. The descriptions which were finally adopted and a glossary of terms appear in Appendix II.

Members of the task group tested the system by "slotting" the professional R&D personnel within their own organizations. The

results, as reported at a meeting in January, 1960, were gratifying in that little difficulty was experienced in "sorting" personnel into the seven broad levels.

To assess the utility of the suggested level descriptions, the following information was requested from 32 participating organizations:

(*a*) A list of the position titles applicable to each of the level descriptions.

(*b*) The minimum, midpoint, and maximum salary for each level.

(*c*) The per cent of professional population falling into each level.

Position titles were requested in order to determine the consistency of nomenclature along with frequency of usage. Salary data were requested in order to determine if a distinguishable pattern in salary progression existed.

Similarly, data were desired on the per cent of personnel in each level in order to determine if a pattern existed in the distribution of the technical population. Comments were solicited in an effort to further improve the effectiveness of the level descriptions.

Twenty-seven of the 32 company sample responded and the results were reported in an interim progress report delivered to the Personnel Committee in May of 1960. Briefly, it was concluded that the level descriptions were valid and represented a basis upon which a total IRI survey could be conducted.

In July of 1960, requests for data were sent to 139 IRI members which combined with the original 32 company sample gave a potential total of 171 contributors to the survey. In late 1960, new members increased the total to 174 potential contributors.

The response was as follows:

Total Companies Contacted	Total Responses	Total Responses With Data	Total Responses No Data	% Response
173	119	108	11	69

Data Analysis

The companies were arbitrarily divided into the following industry groups to determine the possible existence of specific industry patterns:

(*1*) Petroleum Refining and Extraction
(*2*) Chemicals and Chemical Processing
(*3*) Pharmaceuticals
(*4*) Electronic and Electrical Manufacturing
(*5*) Fabricated Metal Products
(*6*) Primary Ferrous and Non-Ferrous Metals
(*7*) Glass, Rubber, Plastics, and Paper Products
(*8*) Food and Grain Products
(*9*) Miscellaneous

Table I shows the response pattern by industry group.

TABLE I

Response to Survey

Industry Group	Number Companies Contacted	Number Responses With Data	Number Responses No Data	Total Response	% Response
Petroleum Refining and Extraction	21	15	3	18	86
Chemicals and Chemical Processing	42	26	1	27	64
Pharmaceuticals	10	6	0	6	60
Electronic and Electrical Manufacturing	26	15	4	19	73
Fabricated Metal Products	18	7	0	7	39
Primary Ferrous and Non-Ferrous Metals	15	11	0	11	73
Glass, Rubber, Plastics, and Paper Products	22	16	1	17	77
Food and Grain Products	11	7	1	8	73
Miscellaneous	8	5	1	6	75
Totals	173	108	11	119	69

A digital computer was used for the analysis of salary information and per cent distribution of personnel. Title usage was analyzed with the help of a standard punched card and sorting system. The use of data processing techniques resulted in a reduction of approximately 75% in the man-days of effort required for the analysis.

The term "average" is used in this report to represent the simple arithmetic average of data received.

Summary

Titles. The titles used in technical Levels I through V are shown in Appendix III. Titles used for Level III—Administrative and Level IV—Administrative are shown in Appendix IV.

Level I. Among 44 different titles submitted, the most frequently used were:

	Frequency	% Response
By Discipline (physicist, chemist, etc.)	45	28.3
By Discipline prefixed by "Research"	21	13.2
By Discipline prefixed by "Junior"	16	10.1

Level II. Among 49 different titles submitted, the most commonly used were:

	Frequency	% Response
By Discipline prefixed by "Research"	33	19.9
By Discipline	24	14.5
By Discipline prefixed by "Senior"	18	10.8

Level III. Among 56 different titles submitted, the most frequently used were:

	Frequency	% Response
By Discipline prefixed by "Senior Research"	20	11.8
By Discipline prefixed by "Research"	18	10.7
By Discipline prefixed by "Senior"	18	10.7

Level IV. Among 51 different titles submitted, the most commonly used were:

	Frequency	% Response
Research Associate	22	18.0
Senior Research Associate	10	8.2
By Discipline prefixed by "Senior Research"	9	7.4

Level V. The pattern of title usage in Level V was less distinct than in other levels, as evidenced by the use of 29 titles other than the three below which were used most frequently.

	Frequency	% Response
Research Associate	7	12.7
Senior Scientist	6	10.9
Senior Research Associate	5	9.1

Level III—Administrative. Among 60 different titles submitted, the most commonly used were:

	Frequency	% Response
Group Leader	19	13.4
Section Head	12	8.5
Supervisor	12	8.5
Manager	10	7.0

Level IV—Administrative. Among 51 different titles submitted, the most frequently used were:

	Frequency	% Response
Manager	21	15.1
Director	13	9.4

Salary Data

In the original evaluation of data, the task group observed a pattern of salary ranges for technical Levels I through IV (Level V had not been established at that time). Salary data were requested from the other participating companies in order to test this observable pattern as well as that shown by the 32-company pilot survey reported in May, 160.

The salary data submitted show a definite pattern. Of interest is the overlap of approximately 50% of one range into the other.

Level	Task Group Observed Pattern[a]	32 Company Survey Pattern[a]	108 Company Survey Pattern[a]
I	400–650	485–728	472–737
II	600–850	637–919	609–950
III	800–1200	797–1216	777–1185
IV	1100–1800	970–1540	975–1511
V	None	1135–1750	1278–1935
III—A	None	887–1344	835–1350
IV—A	None	1175–1826	1102–1810

[a] Average of minima and maxima, dollars per month.

Such an overlap is considered acceptable in many salary structures. An interesting observation is that the salaries for Levels III—A and IV—A, Administrative personnel, are higher than those of their technical counterparts in Levels III and IV. Table II shows the average minimum, midpoint, and maximum salary for technical Levels I through V.

Table III presents similar data for Level III—Administrative and Level IV—Administrative.

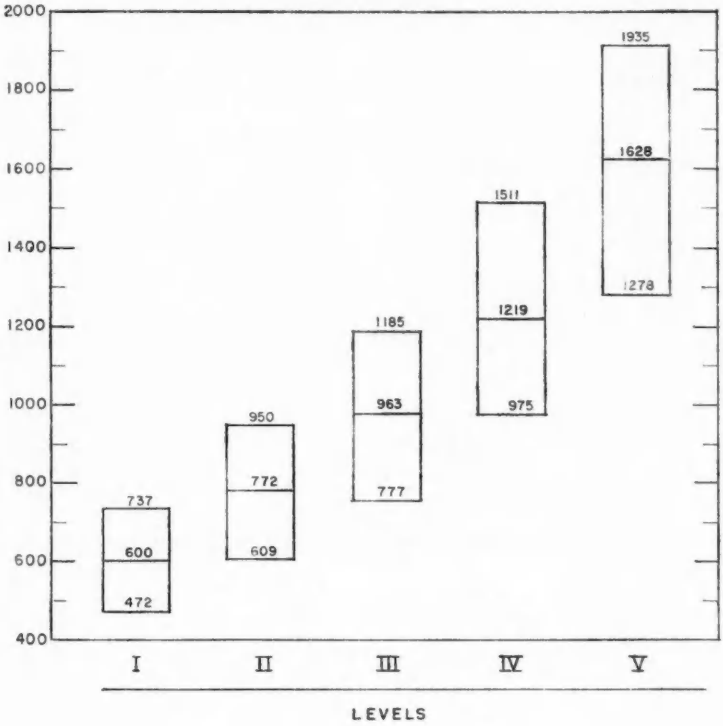
Per Cent Distribution of Personnel

Table IV illustrates the distribution of personnel by level based upon industry groups as well as the overall survey. Initially, the Task Group estimated that over 50% of the professional population would fall into Levels I and II, and less than 1% would be considered Level V. It was important to determine if the company replies would show such a distribution of the technical population. For example, it was felt that the level descriptions would not have been properly written and interpreted if 45% of the professionals were characterized by the Level III description.

The personnel distribution represents a definite pattern which supports the validity of the level descriptions.

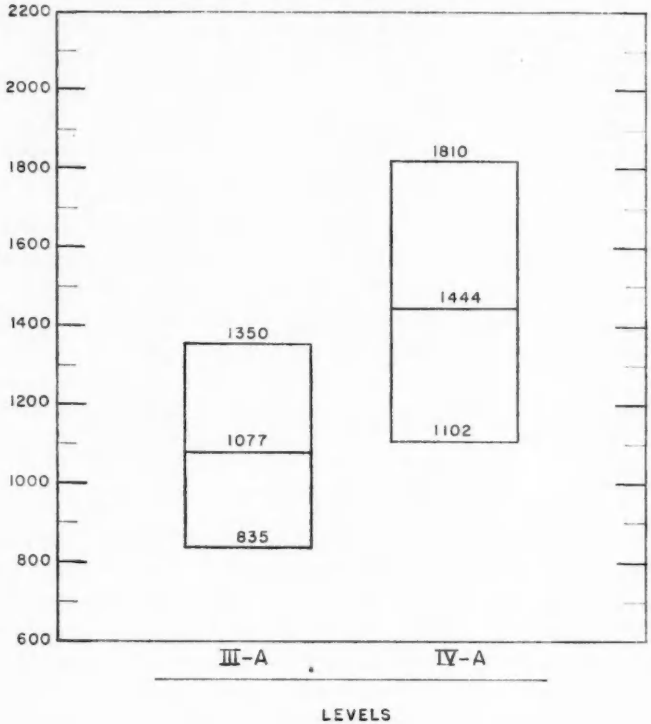
The agreement among industry groups in a given level further indicates a distinguishable level differentiation. For example, in Level II, six of the industry groups were in a range of 30–34%, and three in a 25–30% range.

TABLE II
Salary Ranges[a]
(Technical Levels I–V)



[a] The figures give the averages of minima, midpoints, and maxima (dollars per month).

TABLE III
Salary Ranges[a]
(Administrative Levels of III—A and IV—A



[a] The figures give the averages of minima, midpoints, and maxima (dollars per month).

TABLE IV

Distribution of Personnel
(Average Per Cent)

Industry Group	Level						
	I	II	III	IV	V	III—A	IV—A
Petroleum Refining and Extraction	26.3	31.9	20.9	5.9	1.6	11.5	5.5
Chemicals and Chemical Processing	29.2	32.7	16.1	3.2	1.7	13.6	6.5
Pharmaceuticals	42.9	26.3	15.2	3.1	0.4	7.2	5.5
Electronic and Electrical Manufacturing	20.5	33.9	26.5	8.0	4.4	7.5	5.3
Fabricated Metal Products	33.9	25.3	14.5	6.0	1.3	19.2	7.9
Primary Ferrous and Non-Ferrous Metals	25.1	30.1	20.5	10.6	0.7	12.3	5.2
Glass, Rubber, Plastics, and Paper Products	27.9	34.7	16.9	3.6	1.4	14.0	5.6
Food and Grain Products	24.0	35.0	17.4	13.3	1.0	11.8	7.8
Miscellaneous	29.9	28.0	21.0	9.9	2.0	13.5	5.5
Total Survey	28.0	31.8	18.7	6.1	2.1	12.5	6.0

The summary* of the reported distributions follows:

	32 Company Survey, %	108 Company Survey, %
Level I	29	28.0
Level II	32	31.8
Level III	18	18.7
Level IV	7	6.1
Level V	2	2.1
Level III—A	11	12.5
Level IV—A	5	6.0

* Average of percentages reported.

Survey Comments

The general response regarding the need for accomplishing the objectives of the Task Group and the utility of the level de-

scriptions was very favorable among the 119 participating organizations. An analysis of the replies concerning the utility of the description shows:

Favorable (little or no difficulty in interpretation)	91
Favorable (some difficulty in interpretation)	14
Favorable (considerable difficulty in interpretation)	1
Favorable (doubtful as to success potential)	2
Unfavorable or response submitted without data	11
Total response	119

The fact that 91 out of the 119 companies surveyed reported little or no difficulty in interpretation of the level descriptions *indicates that the levels were well distinguished one from the other.*

Many suggestions were offered as to language which would have made the descriptions closer in terminology to the individual systems of the contributors. By the same token, most agreed that such modification would have been company-oriented and could hinder other organizations with different terminology. *There was no overall pattern in the proposed language changes.*

Four organizations suggested the development of a level description to cover *Level V Administrative* in order to more fully encompass the total R&D structure. The Task Group had previously considered this possibility, but felt that the generic problem of definitive titles, along with information exchange, was of most significance in levels under that of top R&D management.

Two companies indicated the possible *adoption of the seven level philosophy and/or the use of parts of the descriptions* in contemplated reorganization of their systems.

Three contributors suggested the development of an additional level or sub-level for *administrative-staff* positions.

A suggestion was offered relative to the inclusion of *minimum or average years of experience for each level.* The Task Group had originally prepared experience guidelines, but excluded these from the descriptions in order to emphasize the use of position content rather than years of experience in the "slotting" of personnel.

Two respondents pointed out a need for an *additional technical level between Levels I and II, and another suggested* the creation of an *additional technical level below Level III.* It is the hope of the Task Group that once the overall format of the IRI level system begins to receive acceptance by industrial R&D organizations, the development of sublevels will provide even greater utility to the present descriptions. The Task Group recommends that studies be initiated to determine the possibility of describing these sub-levels on the basis of current practice.

One contributor suggested that an effective cut-off date on salaries to be submitted in the survey should be provided. Since the 32 company pilot survey was conducted in April, 1960, and the 108 company survey in August, 1960, the Task Group felt that any salary range increment between those dates would not significantly alter the *pattern* of salaries for each level. Had the intent been to survey salaries, a cut-off date would have been required.

Ten companies indicated that Level IV—Administrative was too broadly written, and should be refined. This suggestion was also made in the 32 company survey reported in May, 1960. At that time, in an effort to better define the level of management involved, the Task Group inserted the phrase "first line management or supervision" into Level III—Administrative and the phrase "second line management or supervision" into Level IV—Administrative. These revised level descriptions were recirculated to 27 respondents to determine the effect upon their original response. All companies replied that the alteration did not affect the data originally submitted. A possible explanation of this situation was offered by one company which suggested that a problem may exist in Levels III—Administrative and IV—Administrative with respect to company size in that Level IV—Administrative description might describe top R&D management in the smaller organization whereas the same description could conceivably be classed by larger organizations as "second line management" only. The Task Group feels that this suggestion is valid and warrants further study by the group.

Many companies indicated *high interest in the overall survey results due to their need for such information* in contemplated reorganization of title and salary structure. The interest in the overall problem is reflected by the 69% membership participation in the program.

SECTION 2

Objective

To obtain IRI member company opinion on preferred titles for the seven IRI level descriptions.

Background

The results reported in Section 1 were received with considerable interest by members who attended an open meeting of the Personnel Committee at the Fall, 1960, meeting of the Industrial Research Institute. The Personnel Committee concluded therefore that IRI companies would desire and should have the opportunity to consider a system of titles representative of the seven level descriptions.

In December, 1960, a *Title Preference Questionnaire* was sent to 173 member companies with the following results:

Total Companies Contacted	Total Responses	Total Responses With Data	Total Responses No Data	% Response*
173	136	124	12	78.6

* The per cent of response represents the highest ever achieved in an IRI-sponsored survey.

The unique aspect of the *Title Preference Questionnaire* was the selection of titles independent of individual company considerations such as tradition, history, or environment. The choice of

titles used in the questionnaire was based upon the most frequent usage as shown in Section I.

Summary

Appendix V shows the results of the company responses. The titles most frequently selected were:

Level		Frequency	% Response
I	By Discipline	74	59.7
	By Discipline prefixed by "Junior"	31	25.0
II	By Discipline prefixed by "Research"	84	67.7
	By Discipline	28	22.6
III	By Discipline prefixed by "Senior Research"	75	60.0
	By Discipline prefixed by "Research"	32	25.6
IV	Research Associate	72	60.0
	By Discipline prefixed by "Senior Research"	29	24.2
V	Senior Research Associate	60	51.7
	Research Fellow	40	34.5
III—Administrative	Section Head	48	39.0
	Group Leader	40	32.5
	Supervisor	33	26.8
IV—Administrative	Manager	62	50.8
	Director	42	34.4

An example of the contemporary paradox in titles is illustrated by preference on the part of thirty-one companies towards the use of the *By Discipline prefixed by "Junior"* title for Level I. On the other hand, seven companies asserted that the use of the term "Junior" was undesirable, or wholly unacceptable for professional personnel.

One respondent indicated the use of a single title for all R&D professional personnel, while another participant used a single title up to a top technical level entitled "Fellow." One company uses a disciplinary title only (chemist, physicist, etc.) for each person in the professional group.

Four companies suggested that an additional technical level between Levels I and II be developed.

One participant expressed concern about developing a uniform title system since the selection of a title was felt to be very individual and company-oriented in nature. Another organization stated that it would be most difficult to have an overall list of titles to be used by both large and small research and development organizations. Another felt that it would be difficult to use the seven-level concept in a research group of approximately 100 personnel.

One organization indicated dislike for the title of "Research Fellow" because of its common usage at universities for doctoral and post-doctoral students. Another participant stated that the word "development" would be substituted for the word "research" in titles for the functions in which that word is more descriptive.

Ten companies took note of the vital need for some uniformity in scientific and administrative titles, and also expressed their satisfaction with the progress and productivity of the Personnel Committee study.

The general attitude of the participants can best be summarized by the following quote:

"The 'Job Status' report came at a propitious time for us. We were in the final stages of developing a new dual-ladder system for our Research Division. We are quite naturally anxious that our system of titles should have significance not only within the Research Division and within the corporation, but within the industry as a whole—and, if possible, within all industries.

"It was gratifying to note that the titles we have selected coincide with the trends you indicated in your conclusion for all five technical levels. This is, of course, not pure coincidence inasmuch as we made a reasonably thorough study of existing systems before crystallizing on the one which has been adopted."

Conclusions

(*1*) The diversity of titles in current use makes their utility for general recognition of scientific and administrative accomplishment impossible.

(*2*) Level descriptions were developed which effectively differentiate five technical levels and two administrative levels within the continuum of professional R&D personnel.

(*3*) Within the companies studied (78.6% of total membership) a pattern of common title preference for the seven level descriptions was shown.

Level I	By discipline (Chemist, Engineer, Physicist)
Level II	By discipline prefixed by Research (Research Chemist, Research Engineer, Research Physicist)
Level III	By discipline prefixed by Senior Research (Senior Research Chemist, Senior Research Engineer, Senior Research Physicist)
Level IV	Research Associate
Level V	Senior Research Associate
Level III—Administrative	Group Leader, Section Head, Supervisor
Level IV—Administrative	Manager

(*4*) The seven level descriptions and their associated titles represent a basis upon which industry can establish a uniform title system which will provide meaningful recognition of professional growth and status of an individual on the part of the scientific community and the general public.

(*5*) The seven level descriptions represent a basis upon which more accurate inter-industry information relative to common problems of research administration can be exchanged.

(*6*) The study has produced the essential data which most professional technical societies have, or intend to obtain.

Appendix I

Task Group Members

Chairman: Mr. G. J. Wilson
Director of Research
The National Cash Register Company

Mr. E. F. Cavanaugh*
Director of Scientific Personnel
Armour and Company

Mr. I. Goldman*
Associate Director—Administration
General Telephone & Electronics Laboratories

Mr. A. E. Powell, Manager
Industrial Relations
General Telephone & Electronics Laboratories

Mr. R. D. Wastrom, Manager
Personnel Relations, Stanford Laboratories
American Cyanamid Company

Mr. John C. Robinson, Jr.
Manager—Personnel Division
Hercules Research Center
Hercules Powder Company

Mr. R. F. Moore
Head—Chemical Development Department
The National Cash Register Company

Mr. J. V. Schurman
Manager of Product Development—Oral Products
Colgate-Palmolive Company

Mr. E. J. George
Administrative Assistant to Manager of Administration
Research & Engineering Department
Sun Oil Company

Mr. J. A. Salisbury, Manager
Employment Relations—R&D
Phillips Petroleum Company

Mr. H. A. Harrell, Jr.*
Assistant Manager—Engineering Planning
Hughes Tool Company

Mr. L. D. Norris
Director of Communications Division
Sinclair Research Laboratories, Inc.

* Past Members.

APPENDIX II

The following descriptions represent the continuum of professional development. Also, they represent levels at which professional development may cease.

Level I

General: This is an apprenticeship period with the incumbent progressively developing his professional maturity, judgment, and experience. For the person who continues to develop, this period would cover the first few years beyond the bachelor's degree.

Technical Direction Received: Detailed.

Technical Direction Given: May give general technical direction to several non-professional personnel.

Administrative Responsibility: None.

Scope: Seeks solutions to technical problems. Work may range from the use of defined methods to the exercise of some degree of technical judgement.

Level II

General: At this stage, the engineer or scientist is working at a professional level and could be termed a journeyman in his field. His responsibilities are likely to encompass a project and he receives general supervision from more senior professionals in his area of competence. He *may* be directing one or more technical personnel who are at Level I as well as some non-professional assistants.

Technical Direction Received: General, with responsibility for the choice of decisions and interpretations within the assigned project.

Technical Direction Given: *May* give technical direction to a group of professional and non-professional personnel.

Administrative Responsibilities: None.

Scope: *Plans and executes* complex technical projects; expected to *recommend* the initiation of new projects within existing programs; *prepare* periodic and final reports for review by Supervision.

Level III

At this level there emerges a duality in the direction of professional progression. The two facets are characterized as *Level III—Technical and Level III—Administrative.* The former is characterized by high technical competence and ultimately leads to a technical or scientific expert, in contrast to the latter which has an administrative orientation.

Level III—Technical

General: This level is characterized by concentration in a technical or specific speciality leading to recognition within the company, or the profession, on the basis of technical competence.

Technical Direction Received: Works with little or no technical guidance.

Technical Direction Given: *May* give technical direction to a group of professional or non-professional personnel.

Administrative Responsibilities: Minimal.

Scope: *Plans* and *executes* technical programs within his area of speciality; *expected* to *initiate* new projects within an existing program.

Level III—Administrative

General: This level involves technical supervision with

responsibility covering several projects and a considerable area of classical supervisory problems. Level III—Administrative is normally considered to be first line management or supervision.

Technical Direction Received: Receives general technical guidance from Level IV—Administrative.

Technical Direction Given: Gives technical direction to the lowest organizational entity which normally consists of one to thirty professional and non-professional personnel. Such direction includes the planning, scheduling, and assignment of work within a program area.

Administrative Responsibilities: Normally spends 10 to 30% of his time on administrative responsibilities.

Implements safety, security, and disciplinary policies.

Interviews and *makes recommendations* to hire—transfer—terminate personnel.

Responsible for the orientation and development of pesonnel.

Reviews performances and *recommends* adjustment in compensation.

Scope: *Participates* in the formulation, implementation and termination of problems, projects and programs.

Performs liaison across company lines.

Insures communication of company interests, objectives, and policies and reviews technical progress.

Recognizes and *pursues* patent potentialities.

Assists in the preparation, editing, and approval of project reports. *Prepares* periodic progress reports to higher management.

May participate in planning and administering the budget.

Originates, initiates, and *directs* new projects within an approved program area.

Level IV

The two directions which emerge in Level III are developed to a much higher degree in Level IV.

Level IV—Technical

General: The technical specialist exhibits superior scientific proficiency and is a recognized expert in his field. He would have minimum administrative responsibilities; be expected to perform advanced studies and to give technical guidance to others in the organization.

Technical Direction Received: Capable of independent work including initiation, planning, and execution of broad program assignments with no professional guidance.

Technical Direction Given: May have technical responsibility for those working with him in his field of specialization.

Administrative Responsibilities: Minimal.

Scope: Conducts independent research and investigations to define and develop the functional theory of a proposed product or process.

Conceives and *expands* theories pertaining to new applications of existing products and/or processes along with the modification of product and/or processes in order to broaden the scope and application.

Invents and *designs* complex products and processes and may assist in engineering these into production.

Analyzes and *evaluates* the scope and objective of inventive ideas.

Level IV—Administrative

General: This level is normally considered to be second line management or supervision with responsibility for a substantial technical activity.

Technical Direction Received: Minimal.

Technical Direction Given: Gives technical direction to one or more organizational entities of professional and non-professional personnel (normally in excess of 25 people). Such activity includes the planning, implementing, directing, coordinating, and interpreting of one or more major technical programs.

Administrative Responsibilities: Normally spends 20 to 60% of his time on administrative duties.

Responsible for safety, security, and disciplinary actions.

Initiates action to hire, compensate, transfer, and terminate personnel.

Responsible for appraising, counseling, orienting, and developing lower levels.

Scope: Establishes program objectives in line with company interests.

Establishes budget for approval by higher management and controls expenditures within the approved budget.

Originates and *initiates* new program areas.

Responsible for inter-and intracompany liaison.

Participates in the formulation, interpretation, transmission, and administration of research and development policy and actions.

Participates in patent decisions.

Reviews and *communicates* technical programs to higher management.

Conceives and *recommends* new programs to broaden the product or process application, modifying the existing product or process and create entirely new products or processes.

Level V

General: In order to emphasize that the scientist can and does

attain growth beyond that of Level IV—Technical, this level would include those personnel who have demonstrated outstanding technical excellence and normally have received national or international recognition of their contributions.

The stature of Level V scientist is comparable to that of the top research and development management function. He covers a wide organizational span for his countributions can affect not only top research and development management, but also corporate management.

The duties of this level are primarily of a consulting and independent research nature coupled with broad latitude for the selection of programs.

Glossary

Program: A group of related *projects* representing a major technical effort to create new technology and/or to develop new products or processes within a broad technical area.

Project: A group of related *problems* representing major subdivisions of a *program.*

Problem: An assignment with narrowly defined limits representing subdivisions of a *project. Problems* are normally assigned to an individual or a small group of individuals.

Professional: Normally holds a degree and is qualified for exemption under the "professional" clauses of the Fair Labor Standards Act.

Administrative Responsibilities: The principal *non-technical* duties and responsibilities which must be met by the incumbent in order to fulfill the function of the level.

Technical Direction: Technical instructions given or received relative to items such as approach, parameters, and phasing of problems, projects and programs.

Scope: The breadth of function within a level described so as to illustrate the comparative weight or importance of the level in the organization.

Organizational Entity: A group operating as an entity in that it represents one of the formal building blocks upon which corporate structure is founded.

APPENDIX III

Technical Title Usage

Level I

	Frequency
By discipline	45
By discipline prefixed by "Research"	21
By discipline prefixed by "Junior"	16
By discipline prefixed by "Assistant"	12
Assistant Scientist	6
By discipline prefixed by "Development"	5
By discipline prefixed by "Associate"	5
Research Assistant	4
Associate Scientist	3
Junior Technologist	3
By discipline prefixed by "Assistant Research"	3
By discipline prefixed by "Junior Research"	2
Scientist	2
Assistant Technologist	2

In addition, there were 30 other titles, used with a frequency of one.

Level II

	Frequency
By discipline prefixed by "Research"	33
By discipline	24
By discipline prefixed by "Senior"	18
By discipline prefixed by "Senior Research"	11
Scientist	9
By discipline prefixed by "Associate"	8
By discipline prefixed by "Development"	5
By discipline prefixed by "Assistant Project"	3
By discipline prefixed by "Project"	3
By discipline prefixed by "Senior Development"	3
Group Leader	3

Research Scientist	3
By discipline prefixed by "Assistant"	2
By discipline prefixed by "Staff"	2
Project Leader	2
Research Technologist	2
Staff Member	2
Associate Technologist	2

In addition, there were 31 other titles used with a frequency of one.

Level III

	Frequency
By discipline prefixed by "Senior Research"	20
By discipline prefixed by "Research"	18
By discipline prefixed by "Senior"	18
Research Associate	11
Senior Scientist	11
Group Leader	10
By discipline	6
Research Scientist	6
By discipline prefixed by "Development"	4
By discipline prefixed by "Staff"	4
By discipline prefixed by "Project"	3
By discipline prefixed by "Senior Development"	3
Project Leader	3
Research Specialist	3
Section Head	3
By discipline prefixed by "Associate Research"	2
Senior Group Leader	2
Senior Research Scientist	2
Engineering Associate	2
Senior Technologist	2

In addition, there were 36 other titles used with a frequency of one.

Level IV

	Frequency
Research Associate	22
Senior Research Associate	10
By discipline prefixed by "Senior Research"	9
Senior Scientist	6
Research Scientist	5
By discipline prefixed by "Principal"	4

Senior Research Scientist	4
By discipline prefixed by "Research"	4
Principal Scientist	3
Research Fellow	3
Scientist	3
By discipline prefixed by "Project"	2
By discipline prefixed by "Senior"	2
By discipline prefixed by "Senior Project"	2
Group Head	2
Group Leader	2
Research Specialist	2
By discipline prefixed by "Senior Staff"	2
By discipline prefixed by "Staff"	2
Senior Engineering Associate	2

In addition, there were 31 other titles used with a frequency of one.

Level V

	Frequency
Research Associate	7
Senior Scientist	6
Senior Research Associate	5
Scientific Advisor	3
Associate Director	2
By discipline prefixed by "Senior"	2
Group Head	2
Research Fellow	2
Research Scientist	2
Senior Research Fellow	2

In addition there were 22 other titles used with a frequency of one.

APPENDIX IV

Administrative Title Usage

Level III–A

	Frequency
Group Leader	19
Section Head	12
Supervisor	12

Manager	10
Section Leader	7
Research Supervisor	5
Section Manager	4
By discipline prefixed by "Project"	4
Assistant Department Head	3
Assistant Director	3
By discipline prefixed by "Chief"	3
Project Leader	3
Section Chief	3
Senior Research Fellow	3
Assistant Manager	2
Division Head	2
Engineer-in-charge	2
Senior Research Group Leader	2
Section Supervisor	2
By discipline prefixed by "Supervising"	2

In addition, there were 39 other titles used with a frequency of one.

Level IV–A

	Frequency
Manager	21
Director	13
Assistant Director	9
Section Manager	9
Section Head	8
Assistant Director–Research	6
Department Head	6
Assistant Manager	4
Department Manager	4
Laboratory Director	4
Research Manager	4
Section Leader	4
Department Director	3
Division Director	3
Research Supervisor	2
Senior Section Head	2
Division Chief	2
Supervisor	2

In addition, there were 33 other titles used with a frequency of one.

APPENDIX V

Results of Title Preference Questionnaire

	Frequency*	% Response
Level I		
By discipline prefixed by "Junior"	31	25.0
By discipline	74	59.7
By discipline prefixed by "Assistant"†	3	2.4
By discipline prefixed by "Research"	16	12.9
Level II		
By discipline	28	22.6
By discipline prefixed by "Associate"†	1	0.8
By discipline prefixed by "Research"	84	67.7
By discipline prefixed by "Senior Research"	10	8.1
By discipline prefixed by "Senior"†	1	0.8
Level III		
By discipline prefixed by "Research"	32	25.6
By discipline†	1	0.8
By discipline prefixed by "Senior Research"	75	60.0
Research Associate	17	13.6
Level IV		
By discipline prefixed by "Senior Research"	29	24.2
By discipline prefixed by "Senior"†	1	0.8
By discipline prefixed by "Principal Research"†	1	0.8
Research Associate	72	60.0
Senior Research Associate	17	14.2
Level V		
Research Associate	15	12.9
Discipline prefixed by "Staff"†	1	0.9
Senior Research Associate	60	51.7
Research Fellow	40	34.5
Level III—Administrative		
Group Leader	40	32.5
Section Head	48	39.0
Section Manager	1	0.85
Supervisor	33	26.8
Laboratory Director†	1	0.85

Level IV—Administrative	Frequency*	% Response
Director	42	34.4
Manager	62	50.8
Department Head	17	13.9
Department Director†	1	0.9

* Where total frequency in a level is not 124, a double submission or no submission was made by company (s).

† Additional titles inserted in the questionnaire by various companies.

THE ART OF THE STIMULATING CASUAL SUGGESTION

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Summary

The encouragement of creativity is one of the most important engineering management tasks. One aspect of this task is providing a productive environment and some building materials. This paper discusses one way this can be done by supervisors who are themselves creative without damping the creativity of their people.

In engineering management—and probably other management as well—there is often the opportunity for the almost incidental or casual introduction of ideas to pace or sustain a problem solution. By properly contributing these ideas the skillful manager can encourage creativity among those who must ultimately solve the problem and at the same time attain some satisfaction for his own creative urges.

Those things the manager has to say which are fundamental to the problem must be explained clearly, maybe more than once.

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But after the problem and any required instructions have been communicated and the problem solving process has begun, the manager can stimulate his people with ideas which are of only possible use. It is important that these ideas be offered and treated by the manager as tentative—to be evaluated and accepted or rejected as the members of the group see fit. This does not mean that such an idea can be offered only once. Those things which, although not fundamental to the problem, stem from related experience or standard practice might be discussed as many times as necessary to insure complete evaluation, but the responsibility of the members of the group to solve the problem must not be infringed if the ideas are to be stimuli rather than depressants.

These tentative ideas, although casually introduced, must, however, be suggested seriously; they must first be considered by the manager thoroughly enough to show that they are free from obvious objections at least. Furthermore, these ideas should not be presented as complete solutions. If they are indeed complete solutions, then they should be presented as part of the assignment of the problem.

Can Everybody Practice This Art of the Casual Suggestion?

Not all executives can muster up the attitude required to operate this way, of course. Those who are inclined to impatience don't like to wait while an idea takes root. Those who have difficulty delegating work are inclined to mistrust their subordinates' ability to give the ideas a fair and vigorous review. And if these managers persist in these attitudes, their feelings will become more and more firm as time goes on because there will be less chance for the demonstration of creative reaction by subordinates.

However, in an environment of delegated authority and responsible and helpful review, the casual suggestion can become a powerful tool in training, improving the level of the program, and putting the manager in more sympathetic contact with subordinates. Even under these ideal circumstances it is important just

how such an idea is introduced, discussed, and summarized. Some people are eager for a chance to duck their normal duties and go after something they think is a pet project of their supervisor. Others have the urge to oppose and destroy anything suggested by some supervisors. These attitudes are two that need to be trained out of these workers, and this training can often be accomplished or aided by developing an improved feeling of confidence between the people involved. The casual suggestion gives them something to talk about and gives the supervisor the chance to invite other suggestions and criticism in a constructive situation as well as to state clearly how much effort he wants directed toward his suggestion. More important, it gives the worker a chance to respond to a situation for which he has not yet accepted responsibility.

The casual offering of ideas is one way engineers making the transition to management can ease the journey. One problem these people have is that of giving up their technical activities to provide time for their managerial operations. As the scope of their assignments increases, the attention to technical detail becomes over-burdening. Those people who can give up the technical details may become successful managers. Those who cannot, carry an additional load themselves and deprive subordinates of proper authority. However, the most immediate contributions a senior person can make to a group are the creative ideas he may conceive. The casual-suggestion concept permits the sowing of these ideas without requiring the detail work of carrying them out. This is perhaps the most effective compromise.

How Well Does It Work?

The casual offering of suggestions does not work equally well for all, of course, and particularly not well for any supervisor who craves recognition for the ideas involved. But, for those with self-confidence, it is a not infrequent rewarding experience to find an idea proposed some time ago appearing in current conversations. The most exciting aspect is the way these ideas sometimes gain

vigor and blossom after passage through two or three minds in as many weeks.

A Caution

The "casual suggestion," as discussed here, is a serious suggestion for the possible solution to part of a current problem. When offered by a manager for the consideration of his people, its purpose is to stimulate them; any satisfaction he gets out of having ideas, he should keep to himself. By the time the idea, if useful at all, is actually implemented, it will have been modified by many new thoughts.

Casual suggestions are no substitute for instructions. People should not come to depend upon them.

In case of emergency, when an idea is absolutely required to solve a problem, the time is past for casual suggestions. The manager must be prepared to shoulder part of the responsibility and work directly with members of his group. He can hope that they will solve the problem, but he must be prepared to do so himself if the group cannot. He cannot take the attitude "Here are a couple of my thoughts on the subject, but it's your reputation that will suffer if you don't find the way to solve your problem."

How, Then, To Practice the Art of the Casual Suggestion and Get the Most Out of It

(*1*) Offer ideas only on pertinent subjects. Don't dilute the group's efforts by getting them off on tangents.

(*2*) Give the idea some preliminary evaluation. Check it against obvious objections and gain some confidence in it.

(*3*) Really offer the idea. Don't expect it to be treated like an instruction.

(*4*) Make sure it is not used as an excuse to avoid working on something covered by instructions.

(*5*) For those who tend to oppose ideas other than their own,

present the idea in the form of questions, leading the conversation toward the idea, rather than pushing the idea out ahead of the discussion. Make sure that these people use facts in their evaluation rather than prejudice or laziness, but in the last analysis be content if the offered idea leads to a new idea on their part which can be used.

(*6*) If you want to know how your idea stood the tests applied by your people, be sure to ask for a report of their feelings. But if you want to economize, just trust them with it.

THE WRITERS' CHOICE: CORPORATION OR CAMPUS?

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During recent years, research administrators have introduced an impressive number of innovations, many of which have been discussed in these pages. Yet one innovation—the hiring of a new kind of technical writer, *viz.*, the writer with a master's or doctor's degree in the humanities—has only rarely been discussed and never, to the best of my knowledge, from the point of view of the writer himself. This lack of discussion is unfortunate for two reasons: it impedes the exchange of relevant ideas between corporations, and more importantly, it implies that both the writers and the administrators are content with the results of the innovation. But as the number of writers in industry increases, as it has been doing every year, so does the need for a definitive administrative policy (or perhaps, more properly, "philosophy") with respect to the functions of writers, particularly since many of these writers are not content.

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Most administrators hire writers for any one of three quite different reasons: to expedite the publication of research results, to ensure that contractually obligated reports meet specified standards, and to improve the quality of reports and thereby enhance the image of the corporation in the eyes of the scientific and engineering community. Each of these reasons is valid, but each poses a different recruitment and managerial problem. Apparently, however, the differences, which even a brief statement can make obvious, are being ignored to the detriment of the reports, the writers, and the corporations.

Certainly management should hire persons skilled in reproduction and printing techniques for they can save time and money for a corporation. They understand the physical requirements for layouts, finished art, photography, composition, paper, presswork, processing, and distribution. Ideally, they can draw upon a wide background of experience to make instant decisions. They know the advantages of various shortcuts, and can estimate time and cost requirements accurately. These persons, however, need not be highly educated: a majority of such writers (generally known as "copy editors") neither have nor require bachelors' degrees.

The same is true of those writers who can ensure that reports meet government standards. Familiarity with MIL Specifications or Contractors Reports Exhibits is solely a matter of training and experience, not of a liberal education. Such writers, for example, may know the exact requirements for the Air Force decimal numbering system without understanding the difference between inductive and deductive presentation. Hundreds of such writers graduate every year from the various technical writing schools in the metropolitan areas and find a welcome place in research corporations. Again, however, many have no more, and rarely need more, than a high school diploma.

The third class of writers is quite different. More and more, research administrators are finding it advantageous to hire persons with advanced degrees in the humanities. Many of these "edu-

cated writers" are familiar with the mechanics of publication and the various military standards, but their chief value lies in their ability to use language as a medium for the expression of complex ideas. They are not scientists, engineers, or technicians; rather, they are authorities on literacy, appropriateness, and the indefinable sense of what is both right and effective in language. Of the three kinds of writers, only the educated writer is concerned with the meaning of reports, only he is skilled in the variety of ways to make that meaning clear, precise, and effective.

Too often the administrators, and as a consequence, the technical and scientific personnel as well, treat this category of writer as simply another service employee. In research corporations, where the chief products—and therefore the primary source of the corporate image—are words in the form of reports and technical papers, this writer, who was expressly hired to improve the quality of reports, has surprisingly little authority. Only a very few have, in fact, more authority than the parts-listers and manual-writers recently graduated from the metropolitan "tech writer" schools. And this blurring of distinctions impedes his work. He cannot function efficiently without the freely given respect of the technical staff. Yet his attempts to achieve that respect are constantly, even if unintentionally, frustrated, with serious results. Many a writer can cite occasions when he was required to justify himself and his work to a relatively unlettered and frequently uncivil engineer. Fortunately, such extreme situations are rare in most corporations, but they undeniably represent a significant attitude. Nor is the engineer wholly to blame: he sees the educated writer working under crowded conditions or moved from office to office to make room for incoming technical personnel; he sees older engineers, who have not kept pace with the rapid advances in technology, relieved of engineering duties and placed in charge of a "Reports Group" that includes writers, typists, artists, photographers, and printers; and he frequently sees the writers themselves—many of them doctors of philosophy—performing the functions of messenger

boys. The engineer can hardly be blamed for assuming that neither the work nor the advice of the writer need be taken seriously.

Many of the writers of my acquaintance were promised a "creative atmosphere" by personnel managers. But they are discouraged by the situation as they find it. They expected more. Most of the writers feel that the situation will not improve. They see only two courses: either adjust to the situation or defect. The results of either course are the same: the writer's intellectual and expressive uniqueness, the single valid reason for his employment, is lost to the corporation.

Perhaps, however, there is hope. Writers are a vocal group and their criticisms are perceptive. If more administrators were aware of the seriousness and universality of the writers' criticisms, the situation could be improved. To this end, I recently asked ten writers (they had a total of twenty-two degrees: 10 A.B.'s, 8 M.A.'s, and 4 Ph.D.'s) for their comments. Many comments were rather harsh, but on the other hand—and without exception—all the writers felt they could perform a highly useful and important service. They held to a common theory of an ideal situation. They believed in their work.

But their common grievances bear notice. One writer, for example, a young man with an M.A. in Greek, expressed the opinion that administrators were, perhaps unwittingly but nonetheless surely, attempting to transform writers into engineers. "They had the good sense to hire us," he said, but they have failed "to exploit our potentialities." Later he asked a rhetorical question that reveals the frustration of most writers: "Why won't they let us do the job we were hired to do?"

Two bright young M.A.'s were concerned with the place of the writer in the corporation. In one case, the senior writer reported directly to an administrator whose salary was considerably less than his own but who was charged with evaluating the work of the writers and conducting salary reviews. In the other case,

the writer reported directly to a vice-president who was sympathetic but who admitted freely that he had no standards to apply in judging the merit of the writer's work.

Another common grievance concerned the "creative atmosphere" promised in recruiting brochures. One former writer, now an instructor at a west coast university, was particularly outspoken, and with some cause. He had been discouraged from reading literary journals during working hours while engineers were being encouraged to read technical journals and were being provided with these journals by the corporation. He had been denied permission to enroll in a literature course during working hours, but he was advised that he might take a course in Introductory Physics. He remains bitter. "I had a belly full," he said. And while his case may be exceptional, it is not unique. He and others like him tend to discourage young men from entering the profession.

There were other complaints, some major and some minor, concerning such things as vacations, office accommodations, the inclusion of writers in conferences, and the fairly widespread double standard of pay scales. And all of these grievances, major and minor alike, form a pattern: the writer, hired because of his literacy, rarely has the opportunity to apply this literacy and as a consequence grows discouraged and eventually dissatisfied. Again, the writer has two choices: if he is economically committed to an industrial career, he can accept the situation and attempt to adjust to it; if he is not so committed, and if he is sufficiently discouraged, he can return to the academic community from which most of the educated writers have been recruited.

I feel strongly about this situation because I firmly believe that it need not exist. Like most writers and former writers, I am proud of the profession. We hold to an ideal that need not be unachievable. Perhaps I am more objective than most because I have left industry to return to the campus, and at a rather lower salary. As a writer, I was frankly discouraged, disillusioned, and even apprehensive. I was unwilling to commit myself to a career

that was at best frustrating and at worst degrading, no matter how well rewarded financially. Even so, I made the decision with great regret.

At least three measures can be taken to slow the growing tide of defection. First, the actual authority of writers can be increased. This would require, for example, that a sharp line be drawn between copy editors and educated writers. Second, writers can be recognized as, and receive the considerations of, professional men. This would affect many things, including salaries and office accommodations, and would help dissipate the subservient (and debilitating) atmosphere that forces writers to justify themselves continually. Finally, writers can be recognized as different from engineers and can be encouraged to maintain that difference. They could, for example, be encouraged to take advanced courses in the humanities, and they should be given some time to pursue their own activities. Implementing these measures, however, will be difficult.

The only alternative to present conditions is a movement of writers back to the campus, and apparently such a movement has already begun. The initial phase, the period of innovation, is over. The administrators are generally pleased. But as one writer said, "The humanist, corporationwise, is nearly fed up." Then he added irony on irony. "And if we leave," he said, "the chatter behind us is going to grow louder and more meaningless, like a latter-day tower of Babel."

Right now he echoes the sentiments of many writers. I sincerely hope he's wrong, because I firmly believe the present situation need not be.

A TECHNIQUE FOR IMPROVING RESEARCH AND DEVELOPMENT COMMUNICATIONS

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Communications is a much belabored word these days. Improved communications is the panacea for all ills in the business world, and I hesitate to add to the deluge of articles on the subject. However, there exists such a real problem in communications between Research and Development, and Corporate Management that it seems worthwhile. I consider that one of the most important jobs of a research director is to interpret Research to Management, and to keep Research informed concerning Management's objectives and general thinking. The failure to have a general understanding of the terminology involved makes this job a difficult one.

A company president may interpret the word "research" to mean anything from the most basic work to plant trouble shooting. He usually has no real opportunity to know more about it than that, unless he was trained in research. When he thinks

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about a new product that is in a state of development, he says to himself that it is in "research," but he has no real idea where it stands.

In order to bridge the chasm that exists, it can be helpful to assign a set of arbitrary definitions that can be understood by everyone concerned. Although the development of a new product from conception to commercialization is really a continuous spectrum, it is convenient to break it down into several parts which are given understandable names. The definitions I suggest are not universal, nor do I propose any campaign to make them so. They are simply tools to facilitate communications.

Definitions

A. Pure Research

Scientific exploration done to satisfy curiosity or to benefit mankind. There is no profit motive involved.

B. Exploratory Research

Scientific exploration generally involving highly trained people using the techniques of pure research, but working in areas known to be of interest to the company.

C. Applied Research

Laboratory work designed to solve a specific problem or build up information about a specific product or process.

D. Technical Development

Pilot plant or semiworks operations to improve the process, provide material for market development, and to develop engineering information for plant design and operation.

E. Market Development

Customer contact at a technical level to provide an assessment of market potential and "feedback" to technical development of information needed for further product improvement.

F. Commercialization

The difficult but important transfer of a new product or a modification of an existing product from market development to sales.

G. Engineering

The transfer of a new process or a modification of an existing one from technical development to manufacturing. This may include the remodeling of existing equipment or the building of new plants.

Very few companies do any Pure Research. Companies that are satisfied with their present areas of operation will probably do only a modest amount of (*B*) *Exploratory Research.* However, those companies that desire to expand or diversify must engage in serious exploratory efforts.

The "satisfied" companies need to have (*C*) *Applied Research,* (*D*) *Technical Development,* (*E*) *Market Development,* (*F*) *Commercialization,* and (*G*) *Engineering* only large enough to support modifications of existing products and the finding of new uses for existing products.

The more ambitious companies must provide additional men and facilities for unrelated new products throughout the rest of the spectrum.

A set of definitions such as this can also be of assistance in explaining the stage of product development to management (and research), and in clarifying corporate research structure and assignments of responsibility.

Exploratory Research would undoubtedly be in a separate unit of every company. Applied Research, Technical Development, and Market Development would be in a central technical unit of companies organized along functional lines, but one or all might be in the operating units of a divisionalized company. Commercialization of improved products certainly would be in the operating divisions. Many companies have separate Technical Development, Market Development, and Commercialization groups for new products unrelated to existing business.

Variations of reporting responsibilities are infinite in number, but regardless of this, responsibility for a product can be assigned definitely when it is located in the product development spectrum.

It is corporate management's responsibility to blend all parts of the product development into a continuous spectrum to get the most efficient use of technical manpower and creativity. Having come up through Research and Development, I was once of the opinion that an intelligently planned research and development program could only be arrived at if there was adequate long range planning on the part of management.

I still believe this, but today I can appreciate that management cannot arrive at any plan in a vacuum. Ideas must come from R&D. In fact, they must come from all parts of the corporation. This can result only from cooperative but individual effort. Full play of creativity must be encouraged. Conformity to the welfare of the corporation is needed, but there is no place for conformity of ideas. It is management's responsibility to take these ideas, fit them together into a composite whole by consideration of fact, opinion, long range plans, and intuition. Then, when the plan is developed, the balance of men, money, and facilities needed to implement it must be provided.

COMMENTARY ON NEW BOOK

Automation—Its Impact on Business and People. Walter Buckingham. Harper & Brothers, New York, N. Y., 1961. $4.50.

The title of this volume is accurately descriptive; the book attempts to define and explain automation and to consider its consequences in modern industry. The author, who is the Director of the School of Industrial Management at Georgia Institute of Technology, presumably has the combined knowledge of engineering and economics that would be the ideal background for the author of such a book.

In the first chapters, which are intended to give the reader an understanding of automation and its origins, there are serious errors. One of the examples used to define "feedback" in the first chapter is the story of the increase in old maids after the decimating Napoleonic wars. More unmarried females kept more cats which destroyed a larger number of mice. Since mice eat bees, there was an increase in bees. It would be trifling to comment on the validity of the sequence; the unfortunate fact is that this example is a story of simple cause and effect, not of feedback. It can represent only an "open" servo system, and not a "closed-loop" system with feedback, unless the number of bees somehow affected the supply of old maids!

A little later the author states that with feedback, machines can stop, start, accelerate, count, inspect, etc. Machines can do all these operations and many more, without feedback. The author also states that "research and development expenditures in the United States have doubled in the last five years to over $7 billion per year." Over $7 billion is technically correct, but when the figure was approximately double that sum in 1960, the author of a book published in 1961 should use better statistics. Too many of the author's facts and examples are either questionable or erroneous.

While there are many valid and excellent points made about the sales of computers, the abilities of computers, and some of the limitations of them, there are also too many unproven statements which are submitted as if they were factual. For example, the statement, "The glamour attached to having the fanciest plants and the most intricate machinery has led to some enormous expenditures that may well go down in history as monuments to conspicuous investment," immediately follows a paragraph giving a series of cost savings and other figures regarding the use of computers. Managers of any modern business who are accustomed to making decisions regarding new plant equipment on the basis of economic return are certainly unfairly maligned.

The consequences of automation are generally better treated than the technical side. Many excellent points are made, including the significant one that the job created by automation often is located thousands of miles from the job which is eliminated. While it is mentioned, the author does not clearly and emphatically make the point that automatic machines make our nation more productive and are the only means of maintaining and increasing our standard of living. Nor does he specifically show that without automation and the consequent lowering of production costs, many a business enterprise would be forced to close, and its employees would be laid off and forced to seek new employment.

Succinct and penetrating statements, such as "Automation does not upgrade people, only their jobs," are mixed with elegant-sounding but meaningless statements like, "There is no reason why labor should be more mobile, flexible, and willing to assume the enormous risks of economic dislocation than the other components of production—capital, management, and natural resources—which are to varying degrees organized, concentrated, and immobilized."

The entire section of the book on the impact of automation leaves a careful reader with a queer feeling that the author is somehow pro-labor, anti-capital, and for the extremes of rigid governmental control. Statements, such as "Second, it is the responsibility of government to guarantee full steady employment and . . .," as well as ". . . in the past, depressions and mass unemployment could not directly be traced to technological progress," are difficult for a businessman to digest. The latter statement is insidious, since it does not boldly state the author's viewpoint. The thought is slipped in, as if depression and mass unemployment is the inevitable consequence of technological progress.

There are a great many other points made by the author which will be disputed by the businessman-reader. The book is filled with much good material, and will be especially valuable for anyone concerned with the impact of automation on business and people. It should be read carefully—for the analytically minded it will be stimulating, interesting, and thought provoking. For the untutored in automation, the volume may mislead at times—inaccuracies are combined with too much of the author's bias.

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Minneapolis-Honeywell Regulator Company
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